APPENDIX D

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ACADIANA BAYS REEF RESTORATION PROJECT

REDUCED LOWER ATCHAFALAYA RIVER FLOW AND SEGMENTED REEF MODELING

1.0 MODELING ADDITIONAL CONDITIONS AND REEFS

1.1 Descriptions of Simulations

The Louisiana Department of Natural Resources (LDNR) requested Taylor Engineering conduct additional model simulations to examine the effects of reducing the Lower Atchafalaya River stream flow and three new or modified reef configurations on the salinity regime in Vermilion, West Cote Blanche, and East Cote Blanche Bays. A freshwater diversion plan, suggested by the LDNR, reduces the stream flow rate entering the system at the Lower Atchafalaya River by 10%. Specifically, the reduced flow model simulated a mean flow rate of 112,500 cfs for the Lower Atchafalaya River compared to the 125,000 cfs mean flow rate used in Chapter 6.0. Figure D-1 details the new simulation flow rates at all freshwater input points.

In addition, Taylor Engineering modified the Acadiana Bays model to examine three new reef configurations (designated alternatives A3, B3, and C3). Each alternative consisted of a segmented reef with its crest at MHW. Reefs A3, B3, and C3 extend from Point Chevreuil at orientations of 225°, 270°, and 180°, respectively. The segmented reefs contain 125-ft toe-to-toe openings, spaced 1-mile apart, along their length. Figure D-2 shows the reef configurations (including the previously modeled, non-segmented A2 and B2 reefs) and Figure D-3 shows a schematic of the segmented reefs.

Table D-1 lists the model alternatives, their stream flow conditions, and their reef configurations. For comparison, this study also includes the results of previous simulations described in Chapter 6.0. The simulations applied the same tide and wind conditions used in the Mean Stream Flow condition described in Chapter 6.0. Figure D-4 shows a typical tide boundary condition and Table D-2 summarizes the tide and wind boundary conditions for all simulations in this Appendix.

Table D-1 Simulation Conditions Summary

Alternative	L. Atchafalaya River Stream Flow (cfs)	Reef
Existing 100%	125,000 (100%)	No reef
Existing 90%	112,500 (90%)	No reef
A3	112,500 (90%)	225° orientation, segmented, crest at MHW
B3	112,500 (90%)	270° orientation, segmented, crest at MHW
C3	112,500 (90%)	180° South orientation, segmented, crest at MHW
A2	125,000 (100%)	225° orientation, non-segmented, crest at MHW
B2	125,000 (100%)	270° orientation, non-segmented, crest at MHW

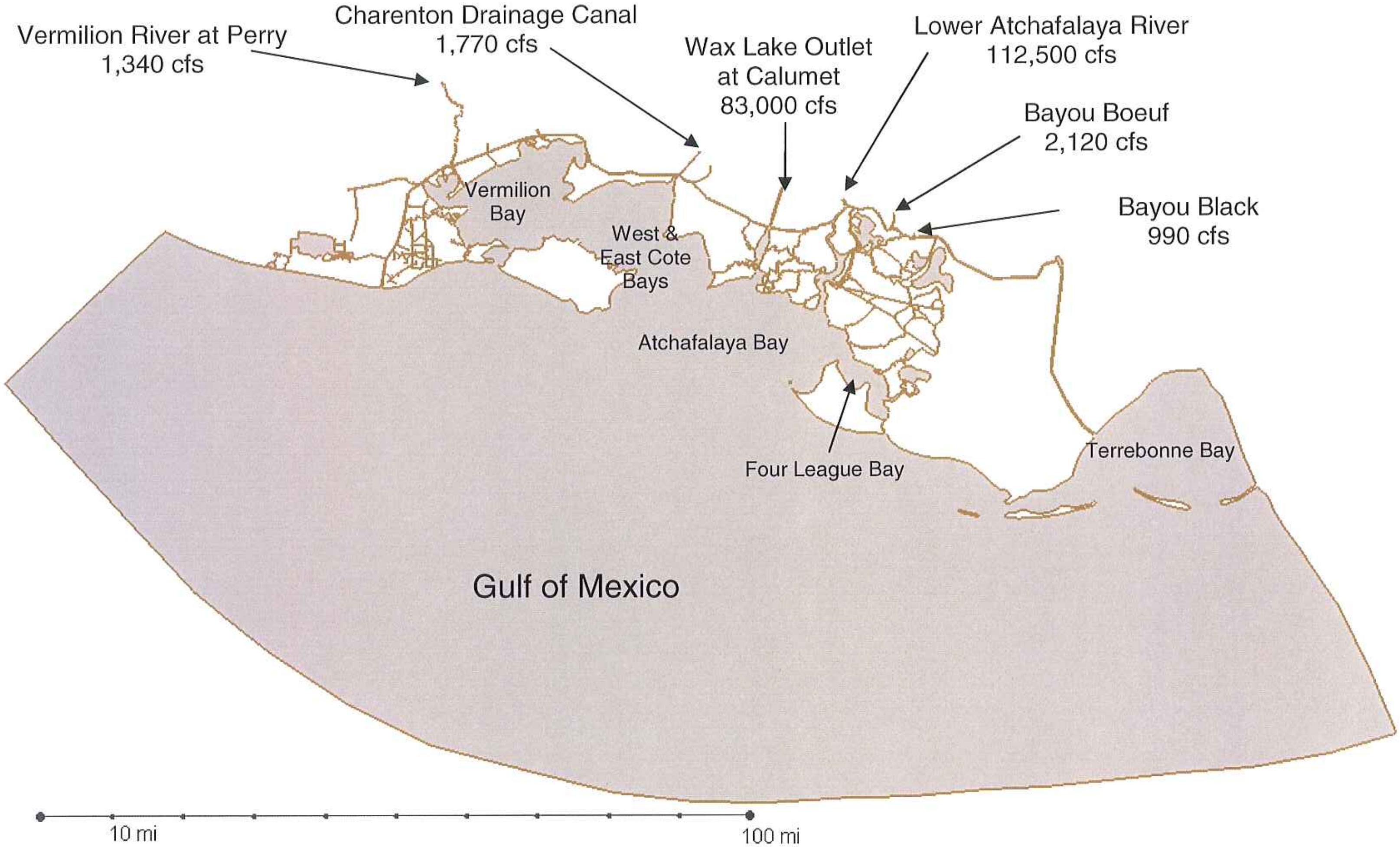

Figure D-1 Stream Flow Rates for Freshwater Diversion Simulation

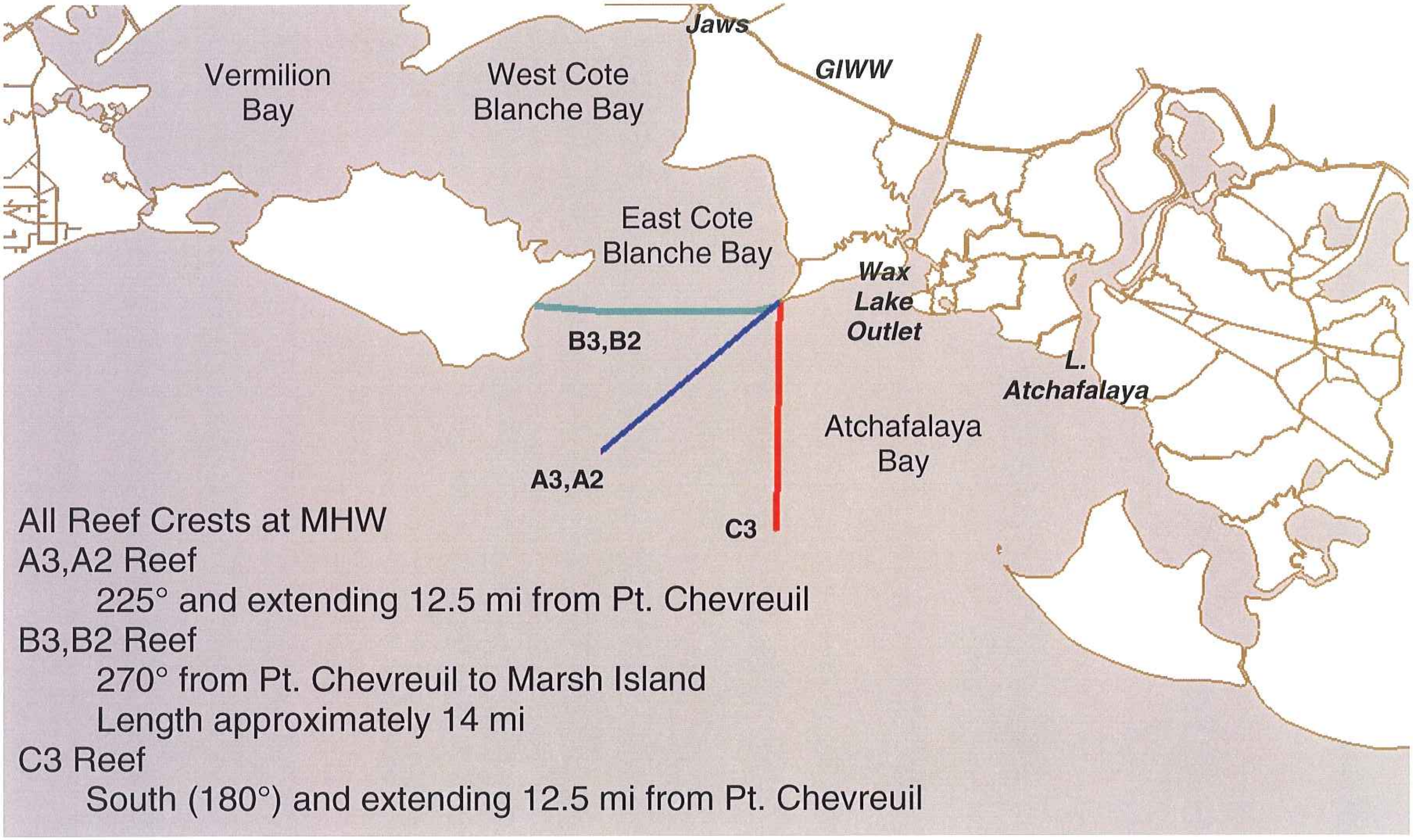

Figure D-2 Reef Configurations

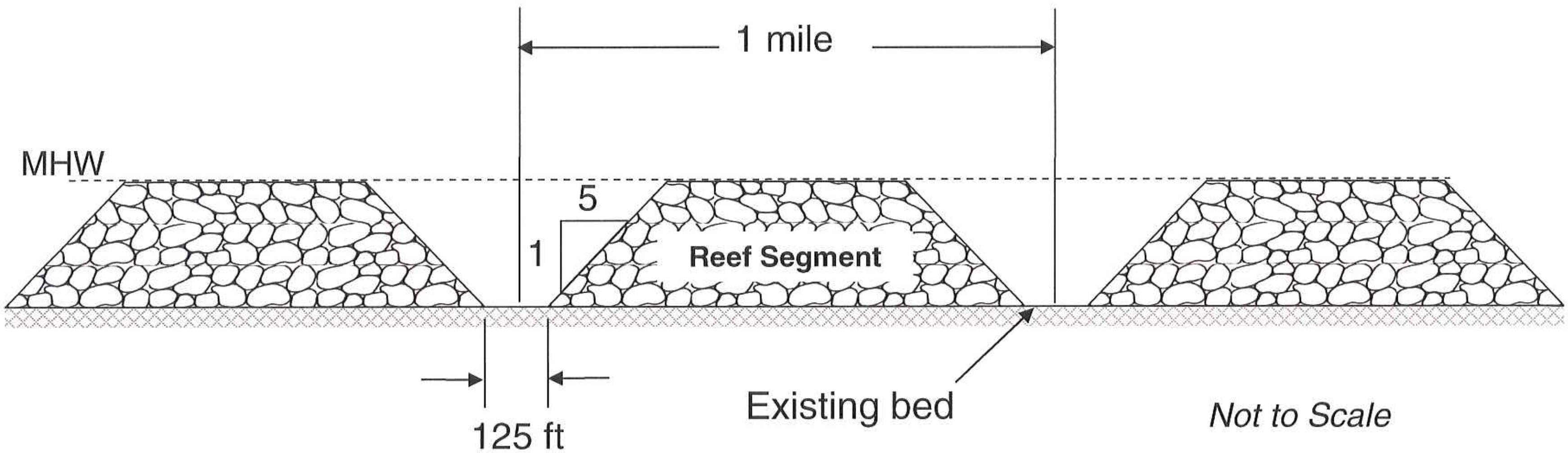

Figure D-3 Schematic Description of the Segmented Reefs (elevation view)

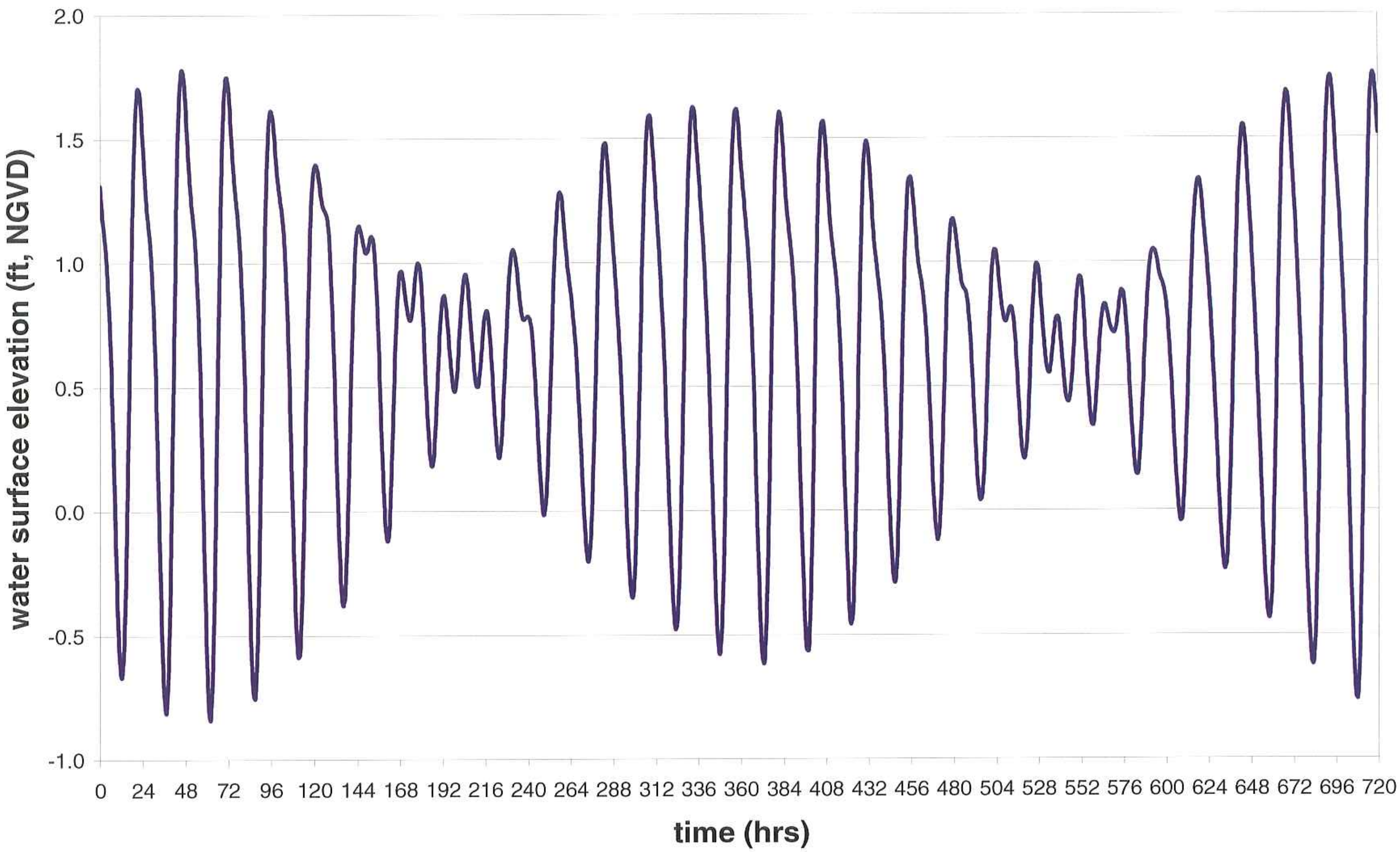

Figure D-4 Typical Offshore Tide Boundary Condition

Table D-2 Summary of Tidal Stage and Wind Boundary Conditions

Tidal Stage Time Series Boundary	Wind Time Series Boundary
January 2001 2 spring tides of 2 – 2.3 ft range 2 neap tides of 0.2 ft range	January 2001 CSI-3 wind average speed of 16 mph maximum speed of 33 mph variable direction, primarily from the NE

1.1.1 Model Results Sampling Locations and Model Output Presentation

Figure D-5 shows the location of the salinity model sampling stations selected for the presentation of model results. As described in Chapter 6.0, Taylor Engineering conducted 28-day simulations of the reduced stream flow with existing bathymetry and each reef alternative (scenarios listed in Table D-1). For each scenario, the model results provided representative quasi-equilibrium salinity concentrations at the stations shown in Figure D-5. The analysis provides bar plots to compare the quasi-equilibrium salinity concentrations and to evaluate the relative effectiveness of each alternative (compared to the baseline alternative — existing conditions with 100% stream flow in the Lower Atchafalaya River).

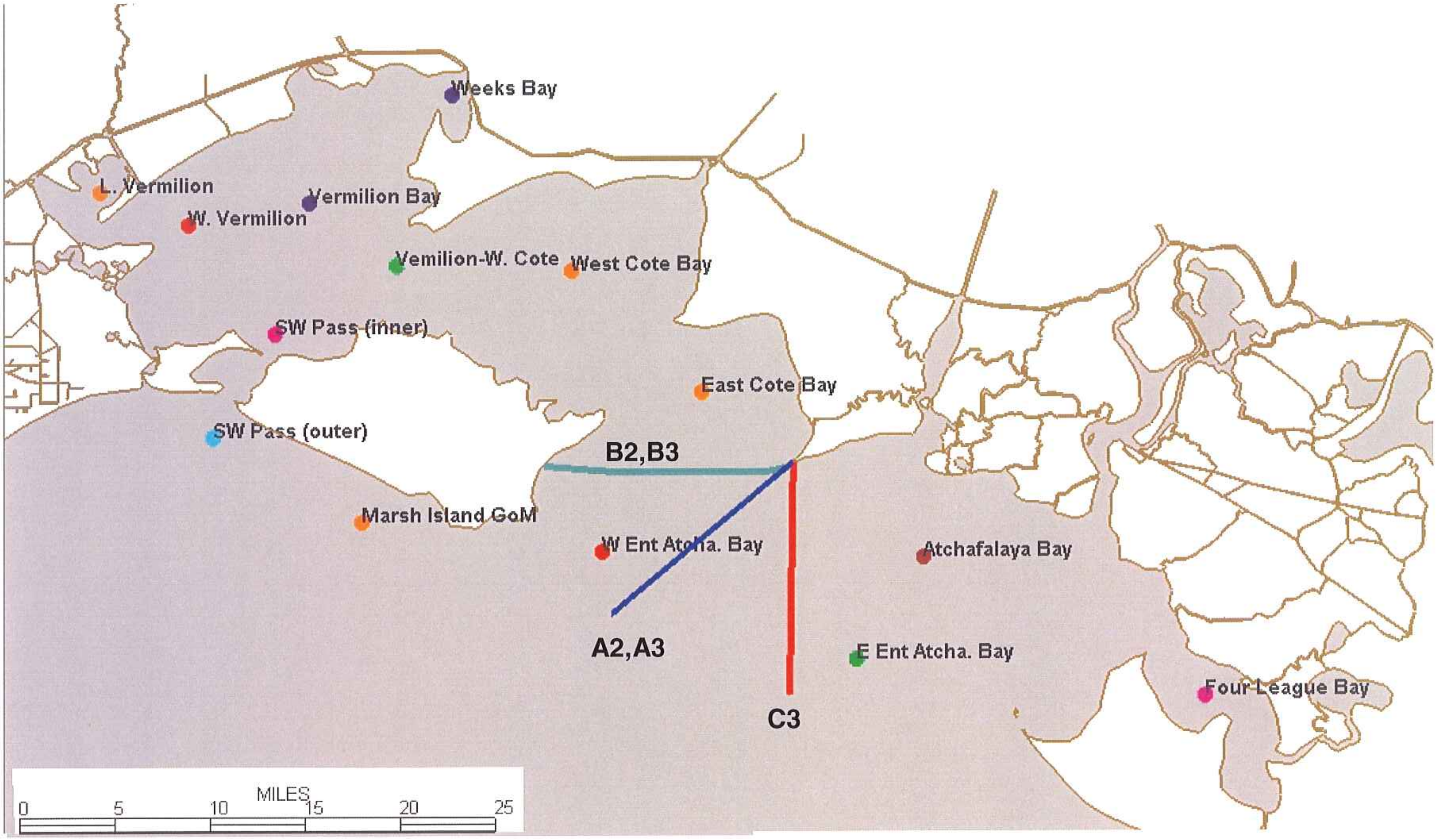

Figure D-5 Model Simulation Sampling Stations

1.2 Model Results

Table D-1 summarized reef alternatives and associated flow conditions evaluated in this Appendix. As seen in the table, all segmented reef alternatives model reduced flow (90% Lower Atchafalaya River flow). Figure D-6 summarizes, at various sampling points, the salinity for the following alternatives: Existing 100% (no reefs with existing flow), Existing 90% (no reefs with reduced Lower Atchafalaya River flow), and the three segmented reef alternatives — A3, B3, and C3 (with reduced Lower Atchafalaya River flow). Figure D-7 summarizes, at various sampling points, the changes in salinity for the Existing 90%, A3, B3, and C3 alternatives relative to that for the Existing 100% alternative. Subsequent figures and discussion compare salinities with reduced flow and segmented reefs to those for 100% flow and non-segmented reefs (A2 and B2) discussed in Chapter 6.0.

The following sections discuss results of the simulations conducted in this Appendix.

1.2.1 Stream Flow Reduction Effects

Figures D-6 and D-7 show the effects of the reduced flow on salinity (compared to the 100% mean flow existing condition). Figure D-6 shows the quasi-equilibrium salinity concentrations, and Figure D-7 shows the salinity change relative to the 100% mean flow existing condition (Existing 100%).

Figure D-7 shows that the flow reduction (without the reefs) increased salinity in Vermilion, West Cote Blanche, and East Cote Blanche Bays with a maximum increase of 0.2 ppt in East Cote Blanche Bay. The effect diminished westward from East Cote Blanche Bay to Vermilion Bay where salinity increased only 0.1 ppt. Outside these bays, the West Entrance Atchafalaya Bay sampling point (see Figure D-5 for location) experienced the largest increase in salinity (5 ppt).

Figure D-8 illustrates the saline and freshwater sources under existing (no reef) conditions. The numbers in the following discussion refer to those in Figure D-8. The reduced stream flow in the Lower Atchafalaya River (1) reduces the freshwater available for transport westward (2) along the shoreline. The reduced freshwater inflow increases the offshore salinity levels, most prominently at the West Atchafalaya Bay sampling point (3), but also at the East Atchafalaya Bay, Marsh Island, and Southwest Pass (outer) sampling points.

Without Wax Lake Outlet, the higher salinity offshore and south of East Cote Blanche Bay (caused by the reduced freshwater inflow to Atchafalaya Bay) would have yielded considerably higher salinity levels in East Cote Blanche Bay as the tide transported the higher salinity water into the bay. However, due to its proximity, Wax Lake Outlet (4) provides the dominant freshwater source for East Cote Blanche Bay. Thus, the reduced freshwater inflow from the Lower Atchafalaya River resulted in only a minimal increase in the salinity levels of East Cote Blanche Bay (and the bays to its west).

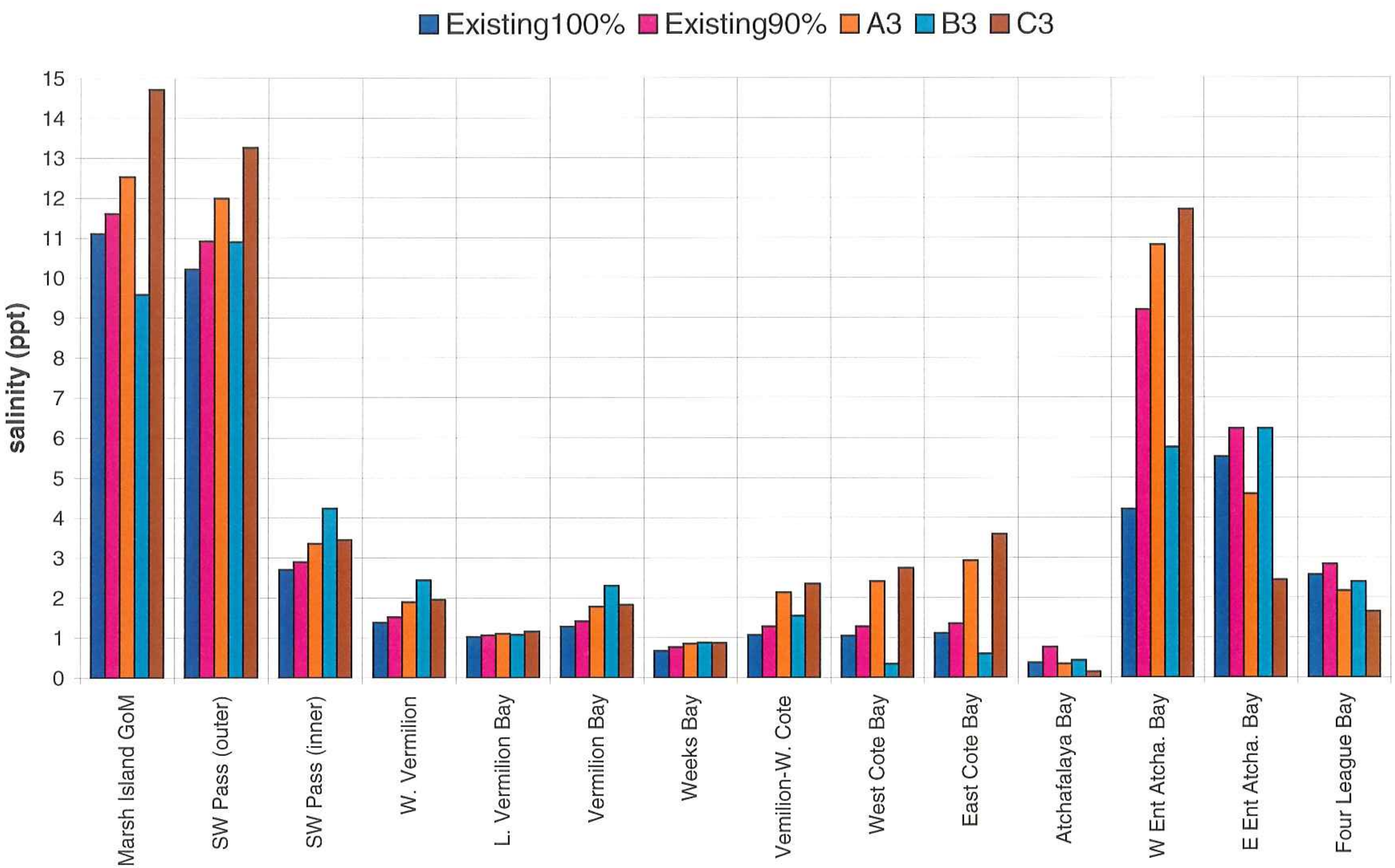

Figure D-6 Modeled Salinities for Existing 100%, Existing 90%, A3, B3, and C3 Alternatives

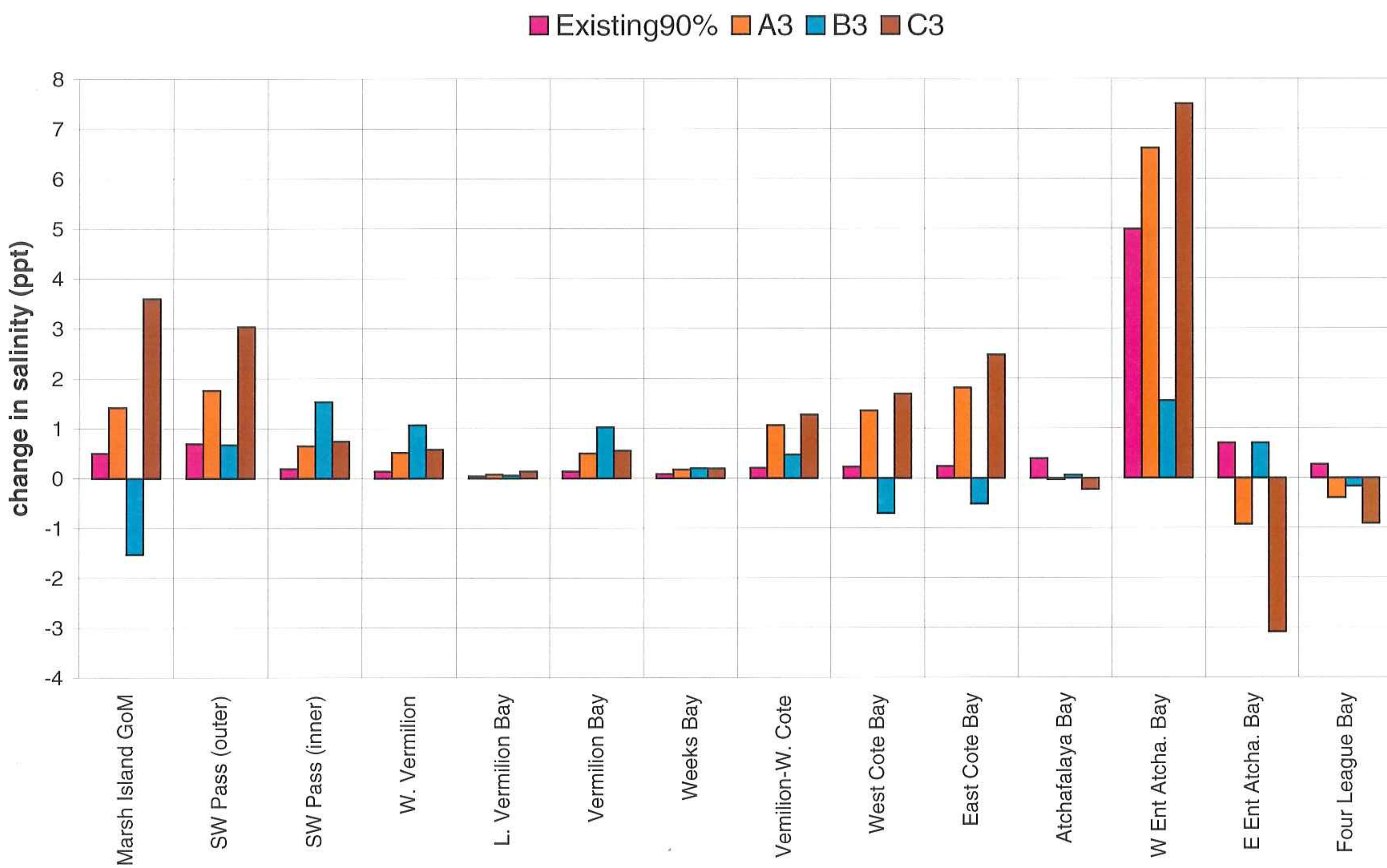

Figure D-7 Modeled Salinity Change for Existing 90%, A3, B3, and C3 Alternatives Relative to Existing 100% Alternative

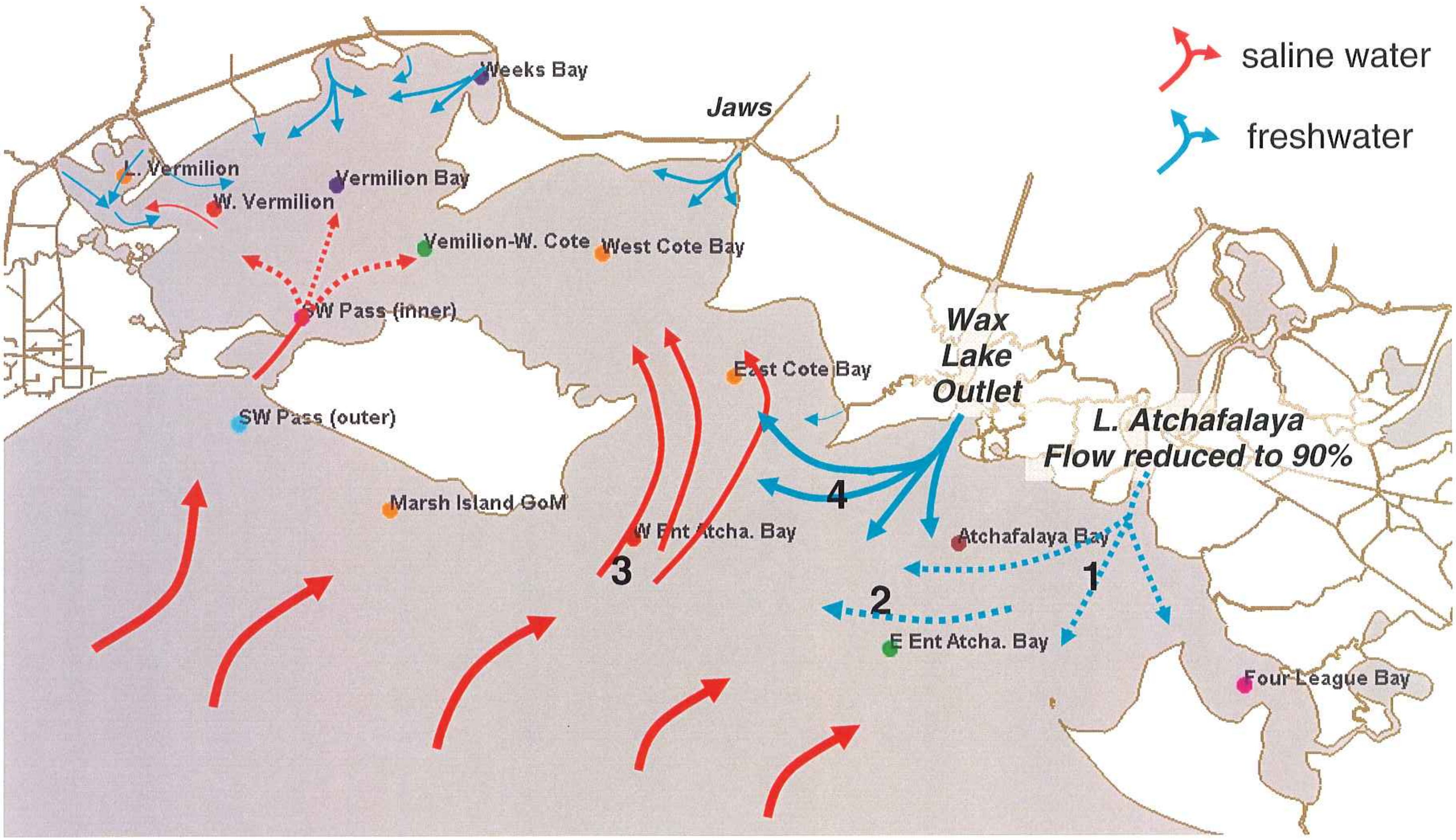

Figure D-8 Schematic of General Flow Patterns for Existing 90% Alternative (Reduced Flow and No Reef)

1.2.2 Combined Reef and Stream Flow Reduction Effects

Figure D-6 shows the effects of segmented reef alternatives along with Atchafalaya River flow diversion. Compared to the Existing 90% alternative, the A3 reef with reduced Lower Atchafalaya River stream flow increased salinity by 0.4 – 1.6 ppt in Vermilion, West Cote Blanche, and East Cote Blanche Bays. The B3 reef with reduced stream flow increased salinity up to 1.0 ppt in Vermilion Bay but lowered salinity by 0.8 – 0.9 ppt in East and West Cote Blanche Bays. The C3 reef with reduced stream flow caused a response similar to that of the A3 reef, but proved more effective by causing an overall salinity increase of 0.4 – 2.2 ppt.

1.2.3 A3 Reefs Effects

Figure D-9 compares the salinity fields created by the segmented A3 reef with a reduced Lower Atchafalaya River stream flow to those for the Existing 90%, Existing 100%, and A2 alternatives (note that Table D-1 presents descriptions of these alternatives). Even with the lower stream flow condition, the segmented A3 reef caused smaller salinity changes than those caused by the non-segmented A2 reef. In general, salinities in Vermilion, West Cote Blanche, and East Cote Blanche Bays were 0.4 – 1.3 ppt lower with the A3 reef compared to those with the A2 reef. In these bays, the A2 reef increased salinity by 0.7 – 3.1 ppt above Existing 100% flow conditions; in contrast, the A3 reef increased salinity by 0.4 – 1.6 ppt above Existing 90% flow conditions.

Figure D-10 schematically illustrates the saline water and freshwater sources and flow patterns with the A3 reef in place. As shown for the existing bathymetry, the stream flow reduction at the Lower Atchafalaya River (1) reduces the freshwater available for transport westward along the shoreline. Both the A3 and A2 reefs deflect freshwater flow (primarily from Wax Lake Outlet) away from East Cote Blanche Bay (2) and force the freshwater plume farther offshore (3) into the Gulf of Mexico where it mixes with saline water. Because of this deflection of the freshwater plume, water entering East Cote Blanche Bay through the gap between Marsh Island and Point Chevreuil (4) has a higher salinity compared to the situation without the reef. However, the gaps in the A3 reef (5) allow some of the freshwater from Wax Lake Outlet to enter East Cote Blanche Bay; consequently, in the Vermilion, West Cote Blanche, and East Cote Blanche Bays, the A3 reef causes smaller salinity increases than the A2 reef.

With the freshwater directed farther offshore, the salinity along the Gulf of Mexico coastline of Marsh Island increases. This condition raises the salinity of the water entering Vermilion Bay through Southwest Pass (6) by about 1 ppt for both reef configurations. However, this water rapidly disperses throughout Vermilion Bay and causes only a slight increase in salinity above existing conditions. The presence of the reefs had no significant effect on the freshwater entering the bays at the Jaws (7) or other points along the Gulf Intracoastal Waterway (GIWW).

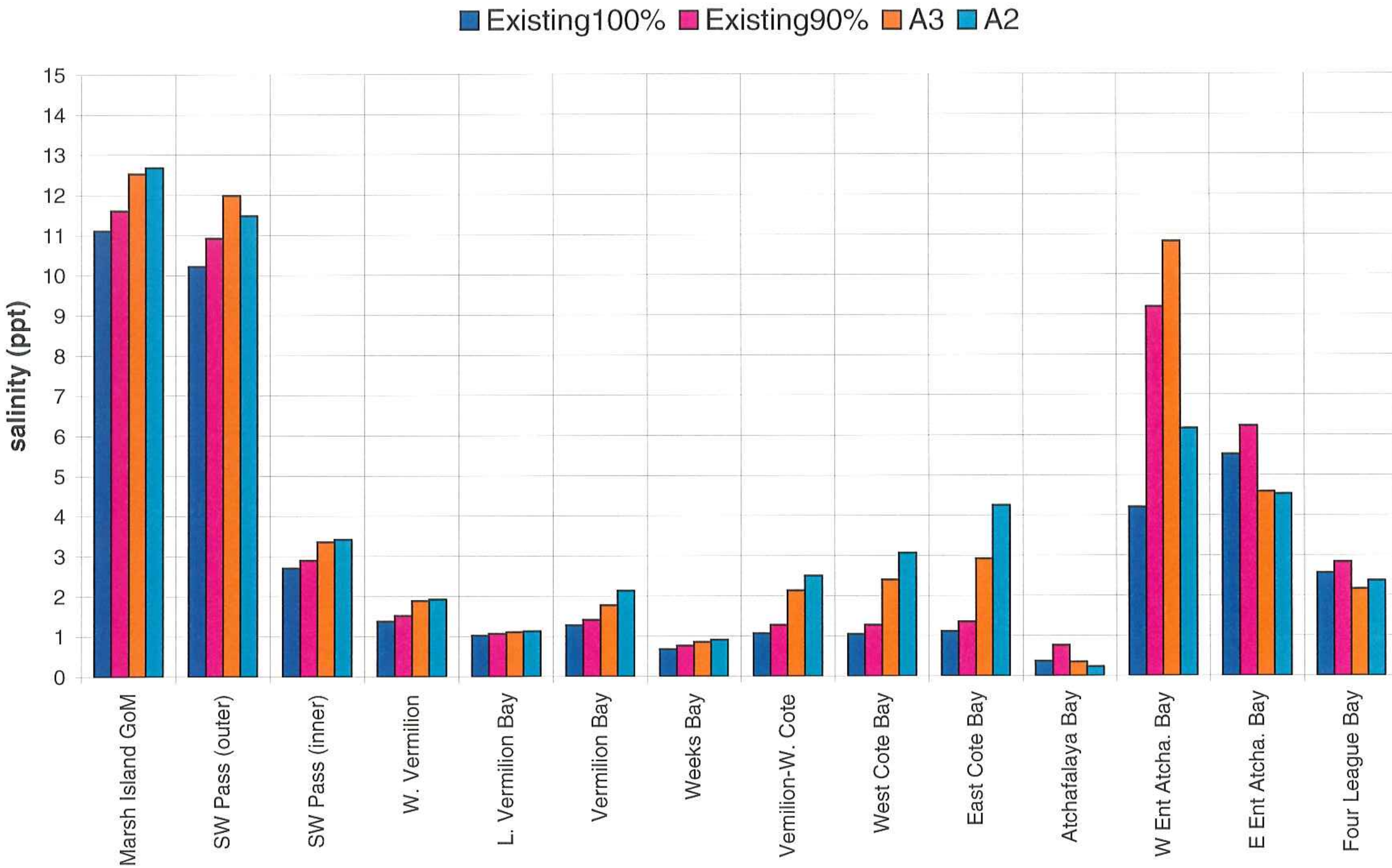

Figure D-9 Salinity Effect Comparison for the A3 and A2 Reefs

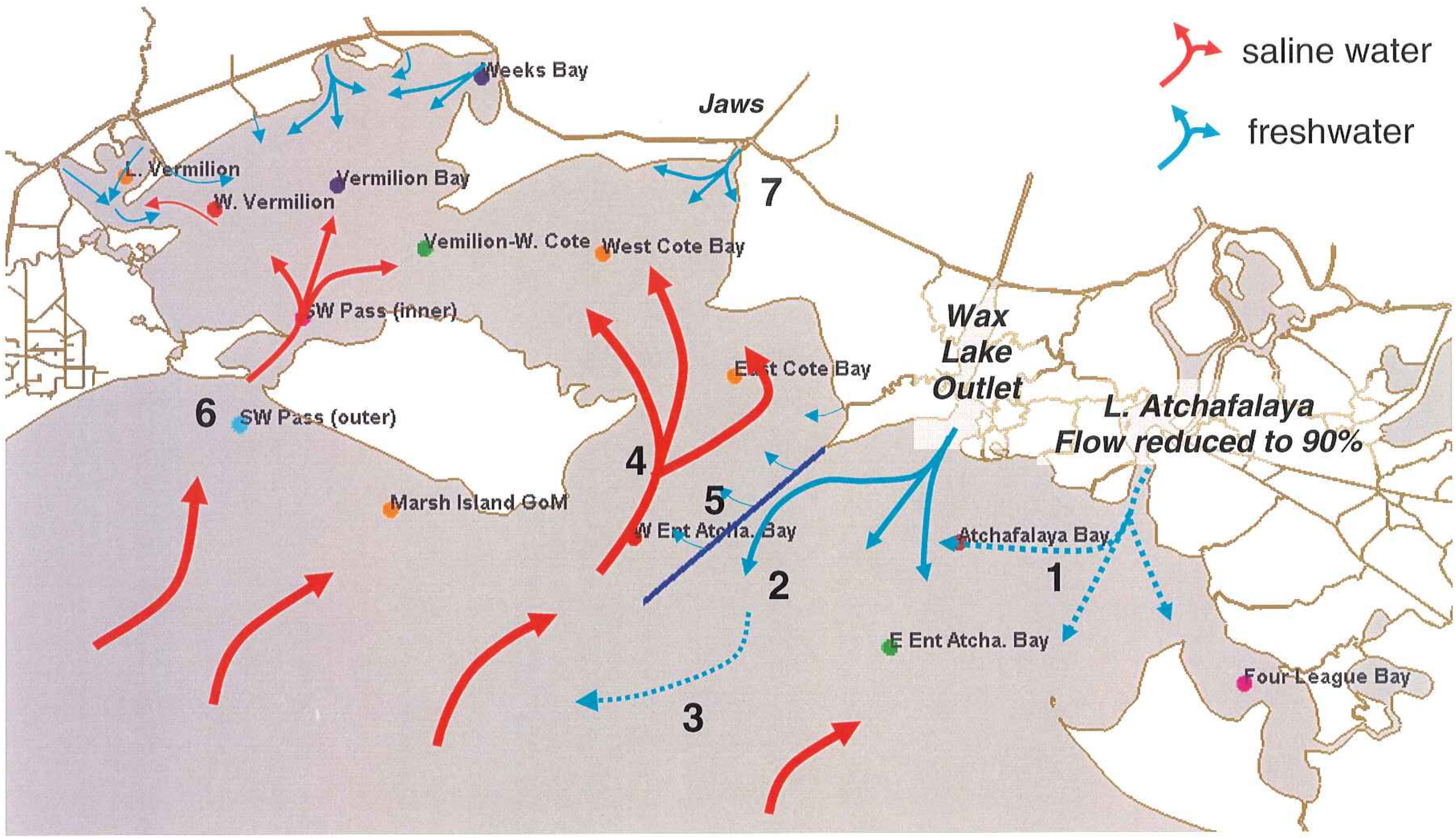

Figure D-10 Schematic of General Flow Patterns for Alternative A3

1.2.4 B3 Reefs Effects

Figure D-11 compares the salinity fields created by the segmented B3 reef with a reduced Lower Atchafalaya River stream flow to those for the Existing 90%, Existing 100%, and B2 alternatives (note that Table D-1 presents descriptions of these alternatives). At the western end of the Acadiana Bays system, the segmented B3 reef with the existing stream flow condition increased the salinity in Vermilion Bay by 0.9 ppt above existing conditions (notably, less than the 1.5 ppt increase for the non-segmented B2 reef). However, by blocking the flow of saline water into East Cote Blanche Bay through the gap between Marsh Island and Point Chevreuil, both the B2 and B3 reefs caused the eastern bays — West and East Cote Blanche Bays — to reach a lower salinity, 0.8 – 0.9 ppt below existing conditions.

Figure D-12 schematically illustrates the saline water and freshwater sources and flow patterns with the B3 reef in place. The flow reduction at the Lower Atchafalaya River (1) reduces the freshwater available for transport westward along the shoreline. The B2 and B3 reefs block the freshwater (2) from both Wax Lake Outlet and the Lower Atchafalaya River from entering East Cote Blanche Bay. However, the reef also blocks the tide-driven saline water (3) of the Gulf of Mexico from entering the bay through the Marsh Island – Point Chevreuil gap. The reef acts as a partial (B3) or complete (B2) barrier to the transport of freshwater emanating from Wax Lake Outlet and the Lower Atchafalaya River and redirects more freshwater offshore (4) compared to the situation without the reef. This freshwater mixes with saline water and reduces the salinity offshore (at the Marsh Island and Southwest Pass (outer) sample points).

Unlike the B2 reef, the B3 reef allows some saline water to enter East Cote Blanche Bay (5), which causes a slightly higher salinity in the bay (0.6 ppt for the B3 reef compared to 0.2 ppt for the B2 reef). For both the B2 and B3 reefs, South West Pass (6) provides the only significant source of saline water to Vermilion, West Cote Blanche and East Cote Blanche Bays. Blocking the Marsh Island – Point Chevreuil gap creates a dead-end system and prevents significant interior circulation (7) from developing between Vermilion Bay and West Cote Blanche Bay. This reduces the movement of saline water from Southwest Pass to the eastern end of the system and results in low salinities east of Vermilion Bay, effectively freshening East and West Cote Blanche Bays due to their freshwater sources.

In contrast to the non-segmented B2 reef, some saline water enters East Cote Blanche Bay from the east because of the segmented nature of the B3 reef. Consequently, on flood tide, an interior circulation develops which opposes the tidal flow from Southwest Pass. The two circulations (the tide from Southwest Pass and the tide from Atchafalaya Bay via the reef segments) create a flow node (virtually no flow) within West Cote Blanche Bay. This condition allows the freshwater from the Jaws (8) to dominate West Cote Blanche Bay and cause a slight reduction in the salinity in West Cote Blanche Bay for the B3 reef compared to the B2 reef.

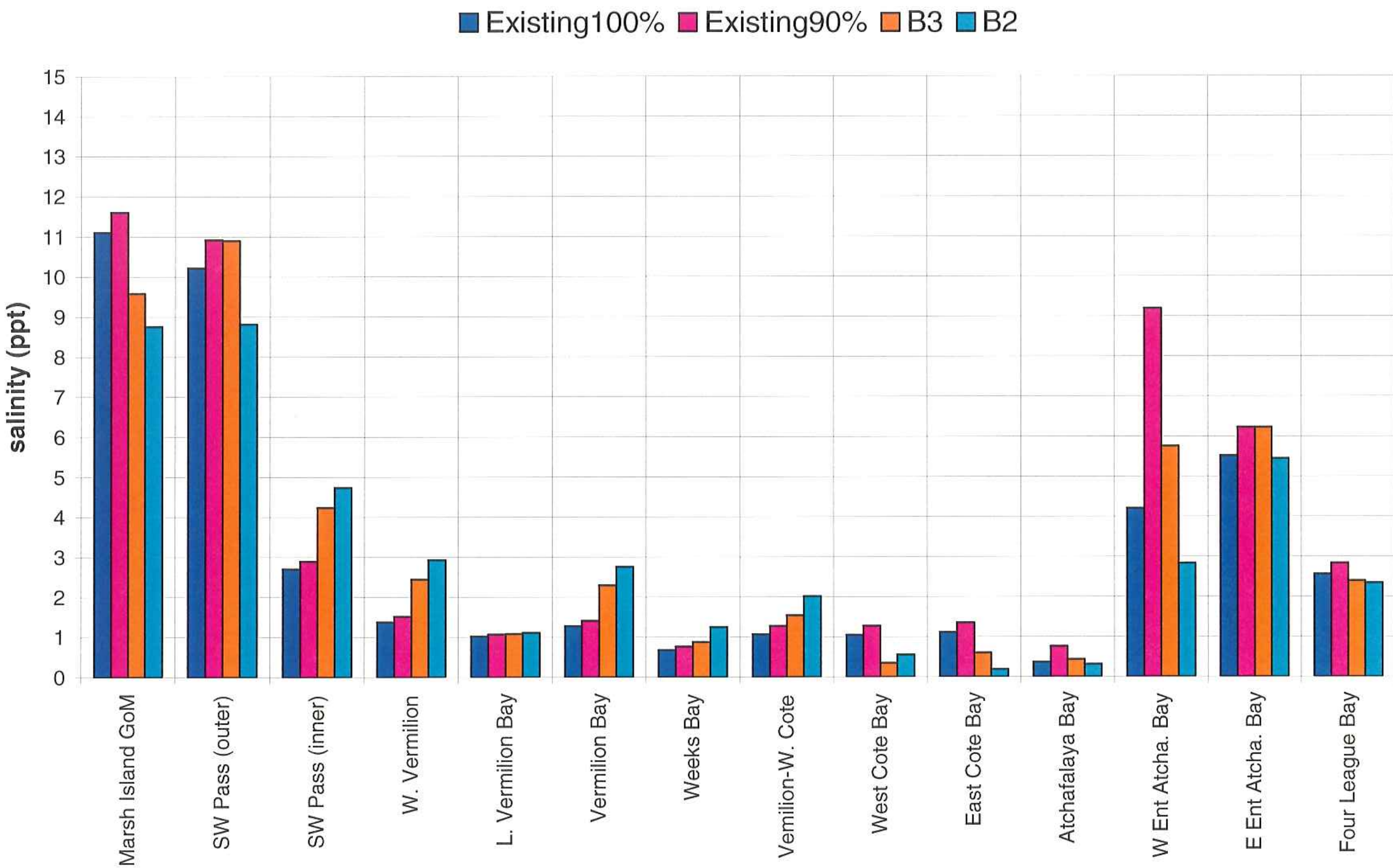

Figure D-11 Salinity Effect Comparison for the B3 and B2 Reefs

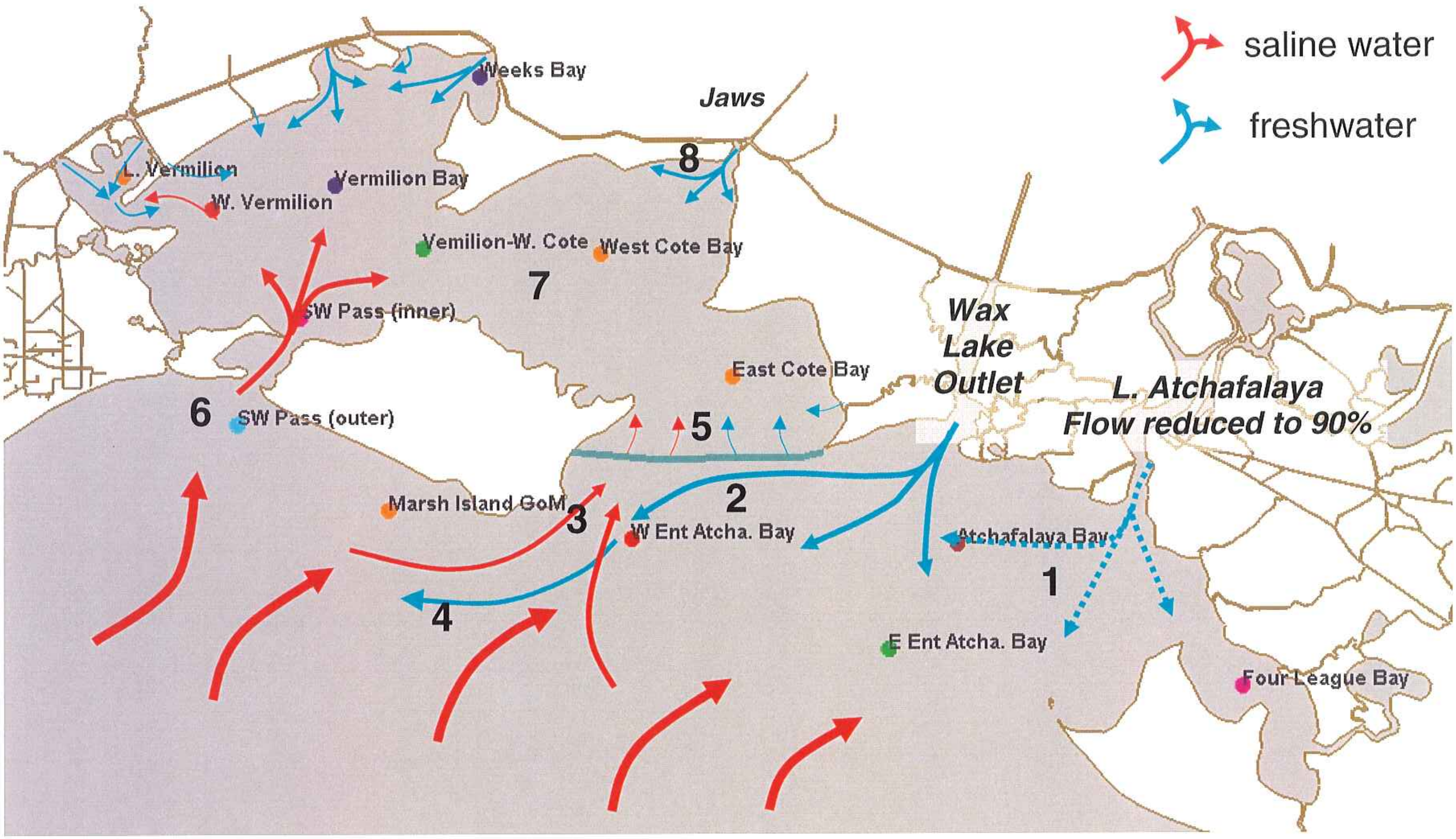

Figure D-12 Schematic of General Flow Patterns for Alternative B3

1.2.5 C3 Reefs Effects

The present study did not examine a non-segmented reef corresponding to the segmented C3 reef. Thus, Figure D-13 compares the salinity fields created by the segmented C3 reef with a reduced Lower Atchafalaya River stream flow to those for the Existing 90%, Existing 100%, A3, and A2 alternatives (note that Table D-1 presents descriptions of these alternatives). The salinities in the Vermilion, West Cote Blanche, and East Cote Blanche Bays for the C3 reef exceed those for the A3 reef by 0.1 – 0.7 ppt. However, in these bays, the non-segmented A2 reef creates salinity increases as high as 0.7 ppt above those for the segmented C3 reef.

Figure D-14 schematically illustrates the saline water and freshwater sources and flow patterns with the C3 reef in place. The flow reduction at the Lower Atchafalaya River (1) reduces the freshwater available for transport westward along the shoreline. The C3 reef deflects freshwater flow (2) from East Cote Blanche Bay. It forces the freshwater plume farther offshore into the Gulf of Mexico (3) than the A3 or A2 reefs. The freshwater plume then mixes with water higher in salinity. In turn, these combined actions result in higher saline water entering East Cote Blanche Bay through the Marsh Island – Point Chevreuil gap.

Compared to the A3 reef, the C3 reef alignment creates a wider flow area for saline water to enter East Cote Blanche Bay between Marsh Island and Pt. Chevreuil. Thus, more water of a higher salinity enters the bay and causes a greater salinity increase (compared to the A3 reef) in East and West Cote Blanche Bays. However, the gaps in the C3 reef (5) allow freshwater to mix with the saline water on the western side of the reef, thus reducing the reef's effectiveness compared to the A2 reef.

With the freshwater directed farther offshore, the salinity along the Gulf of Mexico coastline increases, which raises the salinity of the water entering Vermilion Bay through Southwest Pass (6) by about 2.2 ppt relative to that for the Existing 90% alternative and by abut 3 ppt relative to that for the Existing 100% alternative. However, this water rapidly disperses throughout the bay and causes only slight increases in salinity relative to those for either the Existing 90% or Existing 100% alternatives. The presence of the reef had little effect on the freshwater entering the bays at the Jaws or other points along the Gulf Intracoastal Waterway (GIWW).

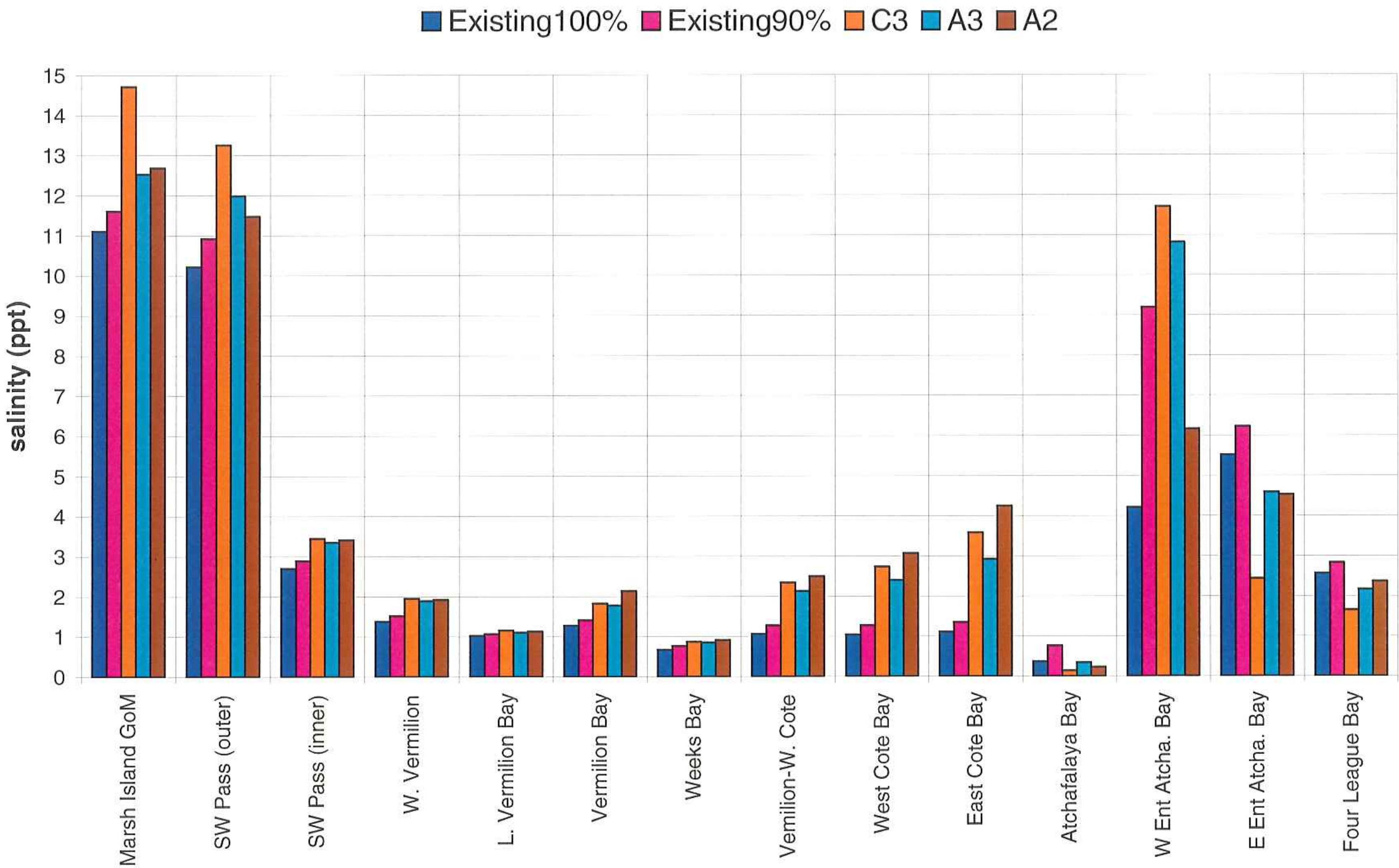

Figure D-13 Salinity Effect Comparison for the C3, A3, and A2 Reefs

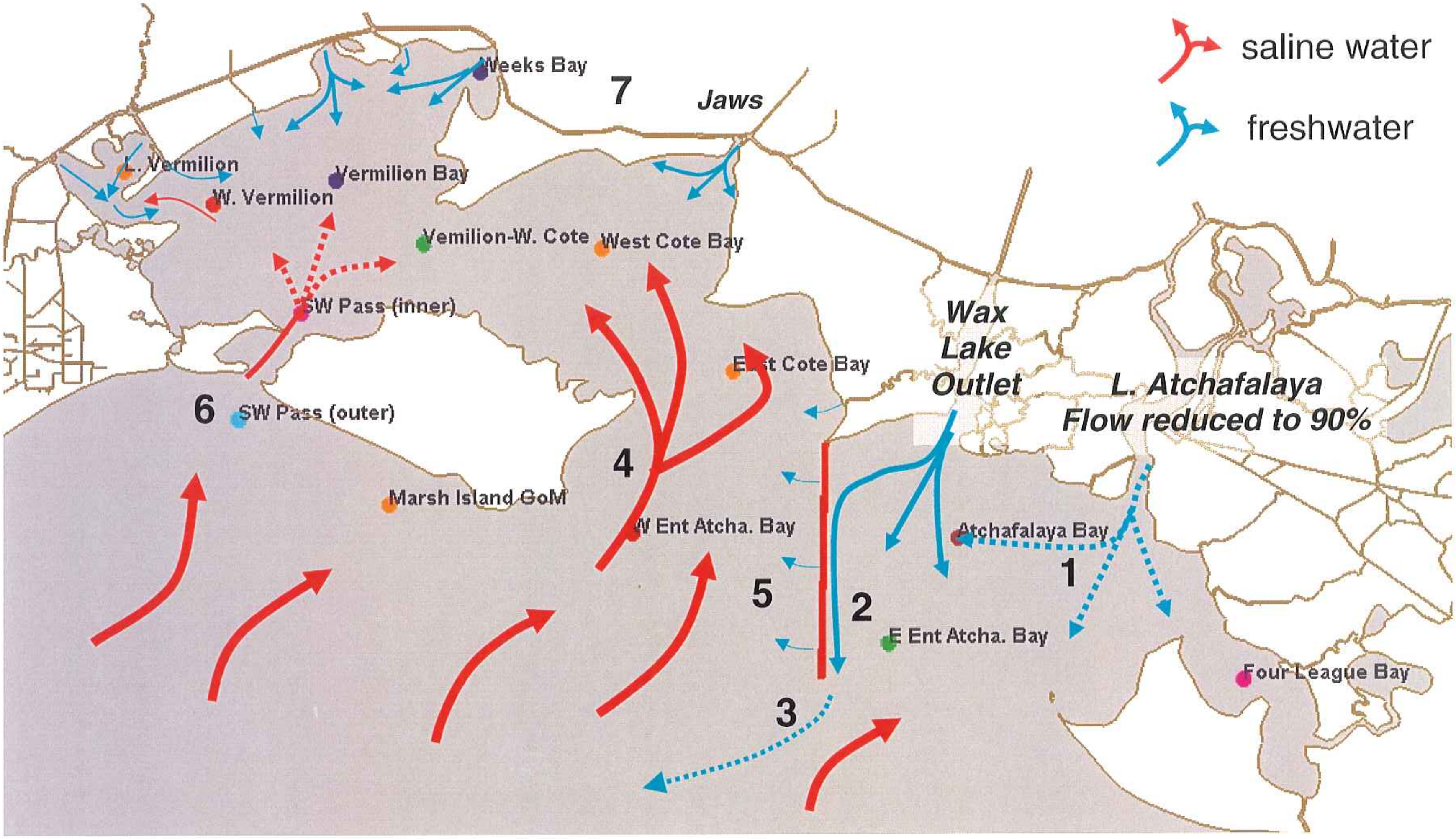

Figure D-14 Schematic of General Flow Patterns for Alternative C3

1.3 Summary and Conclusions

Reducing the Lower Atchafalaya River stream flow rate by 10% from 125,000 cfs to 112,500 cfs marginally increased salinity (0.1 – 0.3 ppt) in Vermilion, West Cote Blanche, and East Cote Blanche Bays. This small increase suggests that the outflow of the Wax Lake Outlet, rather than the Lower Atchafalaya River, dominates the salinity of these bays.

Of the three segmented reefs (all modeled with reduced Lower Atchafalaya River flow), the C3 reef, aligned due-south, caused the greatest increase in salinity (up to 2.5 ppt). The A3 reef (oriented 225° off Pt. Chevreuil) caused smaller increases in salinity than the C3 reef; and the B3 reef (oriented 270°off Pt. Chevreuil) caused the smallest increases. Notably, of the conditions modeled, the non-segmented A2 reef with the existing Lower Atchafalaya River stream flow caused the highest salinity increases — up to 3.1 ppt over existing conditions. This implies that the A2 reef combined with the Atchafalaya River stream flow reduced by 10% would result in still higher salinity increases.